MSC-05814

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

# APOLLO 14 MISSION

# CIRCUIT BREAKER ANOMALY

# ANOMALY REPORT NO. 4





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MANNED SPACECRAFT CENTER

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Anomaly Report No. 4

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# CIRCUIT BREAKER ANOMALY

## STATEMENT

Battery C was not connected to main bus B just prior to entry.

## DISCUSSION

During Apollo 14 entry, at 800 feet altitude, the switches for disconnecting battery busses from the main busses were placed to "off". Although both main busses should have been de-energized by this action, main A remained energized until it was manually disabled by opening the associated circuit breakers after landing.

A preliminary evaluation indicated that motor switch S1 had failed to transfer to "off" (fig. 1). Postflight testing verified this condition; however, had this been the only failure, both main busses would have remained energized until the circuit breakers were opened. Additional spacecraft testing disclosed an intermittent condition within the battery C-to-main bus B circuit (fig. 1). The circuit breaker which connects battery C to main bus B could be closed mechanically by applying nine pounds of pressure to the actuator knob, but an additional three pounds was required to maintain circuit continuity. The condition was repeatable on the bench, and X-rays showed one set of contacts were being held apart by an unidentified substance. Disassembly and microscopic examination of the breaker showed the contacts to be cratered (fig. 2) and partially covered with a sufficient quantity of white crystalline substance to separate the contacts. Chemical analysis of particles removed from the circuit breaker showed both molydisulfide (dry lube) and glass were present.

One component inside the breaker was made of fiberglass which provides a source of glass particles. Glass particles could have become separated from the component, and could have been responsible for the failure.

The possibility that molytrioxide, [a by-product resulting from exposing molydisulfide (dry-lube) to heat] was also explored to determine if it could have caused the problem. The tests results were negative as molytrioxide could not be produced within the circuit breaker environment.

The process specifications and assembly techniques were reviewed and found to be satisfactory. In addition, the cleanliness requirements of the assembly facility were satisfactory.

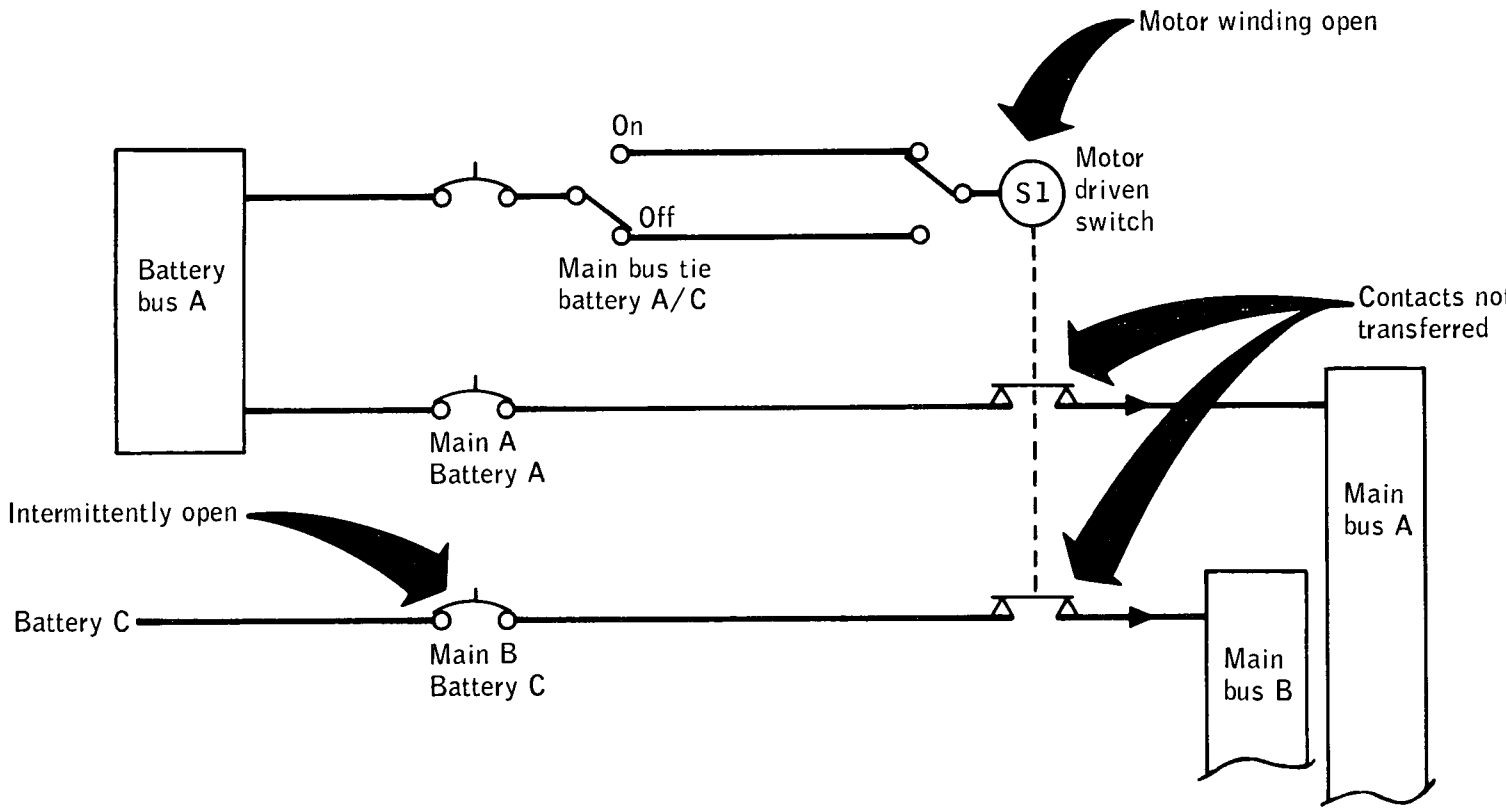


Figure 1.- Bus-tie circuitry.




Figure 2.- Circuit breaker contact with cratering.

The performance history of this type of circuit breaker in the Apollo program shows that approximately 3400 circuit breakers have been used without any previous failures of this type. In addition, there are no criticality-1 single-point failure applications involving these types of breakers.

## CONCLUSIONS AND CORRECTIVE ACTION

Continuity through the circuit breaker in the mechanically closed condition was prevented by a foreign substance, most probably glass particles, on the contact surface. Since this was the only failure of this type in over 3400 units that have been flown and since no circuit breaker is a single-point failure for crew safety or mission success, no corrective action is deemed necessary.